Do parents shape their children to like sweet taste?

Parental influence on preferences for sweetness in pre-schoolers

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Abstract

Children generally have a high acceptance for sweetness, but differ in their preferences for the intensity of the taste. This study investigates how food exposure, parental attitudes and behaviors, and children's taste sensitivity are associated with five-year olds' preferences for sweetness.

Preference data were collected from 135 children at ages four (Mean age: 46.3 months, SD: 3.4, 56% boys) and five years old (Mean age: 57.5 months, SD: 3.3; 58% boys) in a ranking by elimination procedure in the spring of 2015, and 2016. The taste carriers were fruit-flavored beverages and chocolate, both with three levels of sugar content. Quantitative descriptive analysis testified three distinct levels of sweetness in each sample triad. The protocol did not require the child to respond verbally, and included elements of gamification in order to engage the children. In addition, a parental questionnaire enquired about exposure to different foods, parental food attitudes and behaviors as well as socio-demographic characteristics.

Path modelling using PLS-SEM indicated that differences in children's preference for sweetness could be explained by differences in exposure to foods, including more frequent exposure to sweet foods and snacks associated with a higher sweet preference. More frequent exposure to fruit and bitter snacks, were associated with a lower sweet preference for the drink and chocolate, respectively. Parental attitudes and behaviors as well as children's sensitivity to sweetness and bitterness were significantly associated with what foods the children were frequently exposed to.

Keywords: Children; Preference; Sweet; Parental influence; Parental attitude; Sensitivity

1. Introduction

Healthy food habits for children are important both during childhood and in a longitudinal perspective. Food habits are relatively stable throughout the childhood years (De Cosmi, Scaglioni, and Agostoni, 2017; Maier-Nöth, Schaal, Leathwood, and Issanchou, 2016; Mannino, Lee, Mitchell, Smiciklas-Wright, and Birch, 2004; Nicklaus, 2016), and food variety persists from childhood to adolescence and early adulthood (Nicklaus, Boggio, Chabanet, and Issanchou, 2004). To establish healthy habits, it is important to understand the factors that influence these habits. Food preferences have been found to be the main predictor of food habits in children (Liem and Mennella, 2002; Cooke, 2007), and the correlation between food preferences and actual consumption of foods are significantly higher for children than adults (Birch, 1979).

Highlighting the importance of understanding preferences, preference for sweet taste is related to being overweight in children (Lanfer et al., 2012), and a diet with high levels of sugar is not in line with the recommendations for healthy food habits (Commission of the European Communities, 2007; Helsedirektoratet, 2015, WHO, 2016).

2. Theory

2.1 Development of sweet taste

The innate preference for sweet taste is identified and universally accepted (Lawless, 1985; Schwartz, Issanchou, and Nicklaus, 2009), as infants generally prefer sweet taste to no taste (Schwartz et al, 2009, Mennella, Finkbeiner, Lipchock, Hwang, and Reed, 2014). Furthermore, children have a higher preference for sweet taste than adults do (Lawless, 1985; Schwartz et al., 2009). However, there are large differences in preferences for sweetness also among children,

and the reasons for these differences are not fully understood. The higher preference for sweetness in children compared to adults might be due to lower sensitivity, in particular for sucrose (de Graaf & Zandstra, 1999). Supporting the link between taste sensitivity and preference, sensitivity for the bitter agent quinine has been found to indicate a preference for higher sucrose intensities (Duffy, Peterson, Dinehart & Bartoshuk, 2003; Hayes & Duffy, 2008). More bitter-sensitive variants of the bitter receptor gene TAS2R38 have also been associated with both higher sugar intake in children (Joseph, 2015) and sweet preference (Mennella, Pepino, and Reed, 2006). Additionally, adult PROP-tasters find vegetables to be both more bitter and less sweet than non-tasters (Dinehart, Hayes, Bartoshuk, Lanier, and Duffy, 2006), highlighting the complex relationship between sweetness and bitterness, but more research is needed to understand this relationship in children.

Two other individual factors that could influence sweet preferences are age and gender. A general increase in sweet preference through the preschool years has been found (Cooke and Wardle, 2005; Lanfer et al., 2013), but as far as we know, there are no longitudinal studies investigating this with pre-schoolers. Some studies found boys to have a higher liking for sweet items than girls do (Cooke and Wardle, 2005), but regarding preference, other studies did not find a gender effect (Liem, and de Graff, 2004).

Parental health attitudes and behaviours are important throughout the preschool years, as the parents usually decide what food is available for their children at home. Mothers generally do not serve their children food they dislike themselves (Skinner et al., 2002), indicating that food preferences can be inherited through shared environmental exposure.

Additionally, adults with low health concern tend to prefer sweeter foods (Pohjanheimo and

Sandell, 2009), and let their children eat sweets more often (Schneider et al., 2013). This heightened exposure to sweet foods can influence the children in two ways: Firstly, it will familiarize the children to these items, and the children might thus end up preferring higher intensities of sweetness (Liem and Mennella, 2002). Secondly, a high sweet preference might be inherited through modelling, as children learn through observations and modelling from others (Bandura, 1977). Parents are the most important role models for children (Kildegaard, 2011), and might thus model their own preferences on to their children through their own dislikes or likes of certain foods. Support for this model is found in studies indicating that the diet of children is directly influenced by their parents' diet (Brown and Ogden, 2004).

The parental use of food as a reward for good behaviour has been found to influence children's food preferences, and is commonly used (Casey and Rozin, 1989; Schneider et al., 2013). Using food as a reward reinforces the positive relationship towards the food rewarded (Schneider et al, 2013); but only if it is liked (see Cooke, Chambers, Añez, and Wardle, 2011, for a review). The conditioned response to frequently being given sweet foods as a reward might therefore be a heightened preference for sweet items (Birch and Fisher, 1998; Newman and Taylor, 1992). Additionally, a higher preference for very sweet items might develop even though sweet items are rarely consumed, if the sweet items are given as rewards. Children of parents who use food rewards also consume more sweets (Vereecken, Keukelier, and Maes, 2004).

The number of children can also alter the parents' behaviours: Children with older siblings are exposed to more snack foods than children without older siblings (North and Emmet, 2000; Robinson et al., 2007), whereas first-born children are exposed to more fruit and vegetables (Scott, Chih, and Oddy, 2012). North and Emmet (2000) explain this difference as being due to parental time-constraint, increasing the amount of ready-meals and snacks, and decreasing fruits

and vegetables, as well as younger children receiving snacks just because their older siblings do. Hence, family size influences parental behaviours, and therefore their children's food exposure.

2.2 Hypotheses

This study investigates how food exposure, parental attitudes and behaviours, and taste sensitivity, as well as gender and age, together and separately, influence preferences for sweetness intensities in beverages and chocolate

H1. Children's diet influences their sweetness preference

More frequent exposure to foods will influence sweetness preference in three different ways: More high-sweet food and snacks to a higher preference for sweetness, more fruit to a lower sweet preference, and more bitter snacks to as lower preference for sweetness in dark chocolate, and thus a higher preference for bitterness.

H2. Parental attitudes and behaviours influence their children's sweet preferences, both directly and indirectly through their effect on food exposure

Children of parents who use a higher level of food rewards will have a higher preference for sweetness. Additionally, children of parents with less healthy attitudes will be more frequently exposed to sweet foods, and less to both fruit and bitter snacks. Having older siblings also contributes to a higher exposure to sweet food and snacks, and lower exposure to fruits.

H3.Children´s taste sensitivity influence their sweetness preference, both directly and indirectly

Children with a lower sensitivity for sweetness will have a higher preference for sweetness, and will more frequently be exposed to high-sweet food and snacks. We propose that children with a

higher sensitivity for bitterness will have a lower preference for sweetness, and be exposed to more bitter snacks, and less high-sweet items.

3. Materials and methods

3.1. General overview

Two types of data has been collected, both from the first and second year of a longitudinal study investigating taste preferences during the preschool-years from age four to age six. Firstly, sweet preferences in chocolate and drink, as well as sensitivity for sweet and bitter, were tested with children in their kindergartens. Secondly, their parents received Web-based questionnaires regarding both the child's food exposure, and parental attitudes and behaviours. The children were recruited from 16 different kindergartens. In total 175 children were invited of which 145 got parental consent to participate for at least one year during the data collection, and 135 participated during both years. Before each test, the children had to agree verbally to participate. The main characteristics of the participants are given in Table 1.

Table 1. *Main characteristics of the participants*

Year	Respondent population (Invited)	Min age - Max age in months	Mean age in months (SD)	Boys
1	140* (170)	39-51	46.3 (3.4)	56%
2	140* (145)	49-61	57.5 (3.3)	58%

*One hundred and thirty five children participated in the study in both years. Five children dropped out of the kindergartens in the study after Year 1, whereas five new children started in one of the kindergartens between Year 1 and Year 2 in the study.

3.2. Preference and sensitivity testing

3.2.1. Samples

The taste carriers were fruit-flavoured beverages with three distinct levels of sweetness, and chocolate with three levels of cocoa, all prepared especially for this study by the Norwegian company Orkla Foods Norge. The samples were chosen as they were child-friendly, easy to manipulate with three distinct levels of basic taste, and could easily be both brought and served at the different kindergartens. The drinks were served at room temperature, with 10 ml per sample, and the chocolates were offered in two small pieces per sample.

Quantitative descriptive analysis by a professional sensory panel of nine females was used to optimize the samples. Several beverages were produced and profiled, until three with distinct levels of sweetness were chosen. The panel found five additional attributes with significant differences (Figure 1). The chosen beverages differed in the level of added sugar: 4% (low) vs. 12% (medium) vs. 18% (high). For the chocolate samples, the three levels of sweetness were significantly different, and there were also three distinct levels of bitter taste, but there were several other attributes with significant attributes, all displayed in Figure 2 with the spider plot of the chocolate.

The study also included drinks with either added bitter or sour taste, but the data from those drinks are not reported here.

<Figure 1 here>
<Figure 2 here>

3.2.2. Procedure

The experimenters visited each kindergarten four times. One of the visits was to familiarise the children with the experimenters, and the two other sessions were sensitivity testing. The children were twice served four pairs consisting of water samples and diluted taste component, with the four pairs served successively containing either bitter (quinine) or sweet (sucrose) taste. The task

was to discriminate consistently between the two samples within the pair. For the complete protocol and set-up of the sensitivity-testing, see Vennerød et al (2017).

The preference test was conducted at the fourth session. It was generally well understood, and it took approximately 15 minutes to complete the test, but there were large variations. A total of nine experimenters managed the test sessions, and the same two experimenters tested the children each year.

Five children were brought into the room where the testing took place, and the two experimenters introduced the children to a teddy bear with a birthday crown. The children were asked why the teddy bear was wearing a crown, and then if they wanted to sing a birthday song for him. All children participated in the song, and after the song, the experimenters explained that the teddy bear would celebrate his birthday with other bears. The children were invited to help select good drinks and chocolates for his party.

Each child was then tested individually. The child was asked to choose one of three cards placed facedown. The colour of the picture card corresponded to the colour of the cups – blue for all bitter drinks, pink for all sour drinks, and green for all sweet drinks. This was done both to activate and involve the children, and to randomise the serving order samples. A ranking by elimination procedure was then used. The child was asked to take a sip from each of the three cups presented, and then to lift or point at the one that was the best tasting. This sample was then eliminated, the child was asked to again taste the two remaining samples, and then which out of the two was the best. The cups were removed, and the procedure was repeated for both of the two remaining cards. After the drinks, three pieces of chocolate were placed in front of the child, and the same procedure was repeated for the chocolate.

The interviewer always made sure that each child had finished tasting the drink or chocolate before tasting the next sample, and that the children did actually taste each sample. To make sure

that the interviewer's opinions and knowledge regarding the samples did not affect the children's responses, the other experimenter randomized the order of the samples in the set, so the child interviewer was blind to which sample the child tasted at any given time. The words "bitter", "sour", and "sweet" were never used during testing.

3.2.3. Variables

The preference for sweetness consists of two measured variables, preference in drink and preference in chocolate. Each consists of the total preference score for the three samples included. The preference score is calculated by multiplying the rank of the sample (higher rank indicates a higher preference) with the strength of sweetness in the sample (higher strength score indicates that the sample is sweeter). The scores were computed by multiplying the intensity of the sample (1, 2 or 3) with the rank of the sample (1, 2 and 3), and then transforming this to an interval-scale ranging between 0 and 3, inspired by Liem, Mars, and DeGraaf (2004). As an example, if the least sweet drink was the most preferred, the middle drink the second preferred, and the sweetest drink the least preferred, the raw preference score would be computed as 1x3 + 2x2 + 3x1 = 10.

Sweet and bitter sensitivity are both measured variables. Hits (i.e. correct answers) were scored based on the children's performance in the discrimination task, and the indicator is therefore an interval score from 0 (no discrimination in the pair of the strongest tastant) to 4 (correct discrimination in all four pairs). For each test, the total numbers of hits is the indicator for sweet and bitter sensitivity, respectively.

3.3. Parental questionnaire

All parents received web-based questionnaires. If it was not possible or desirable for them to fill it out online, they received the same questionnaire on paper. The parental questionnaire enquired the child's frequency exposure to several characteristic foods for the five basic tastes, and measured parental attitudes and behaviours concerning their child's diet. The questionnaire also included demographic variables. The questionnaires were filled in by mothers (79.8%), fathers (17.3%), or both (2.9%).

3.3.1. Food exposure

In order to measure food exposure, parents reported the child's exposure to 35 food items chosen from an overview of foods containing a high amount of sweetness or bitterness according to a French study using the Spectrum Method (Martin, Visalli, Lange, Schlich, and Issanchou, 2013), and fitted to the Norwegian market. These foods were measured on a scale from 1-5, ranging from "My child has never eaten this" to "My child eats this daily". The majority of the children were exposed to the foods on average at least once, but there were large variations. For example, none of the children had no previous exposure to the Sweet foods and snacks, but 13% of the children had no previous exposure to one or more bitter foods. See Figure 3 for the distribution of exposure to the foods.

Based on factor analysis (described in 3.5.1.), three latent variables were included in the model: Sweet foods and snacks (seven indicators), Fruit (ten indicators), and Bitter snacks (three indicators). Several variables, such as sugar sweetened sodas and fruit juices, had to be excluded from the model in this phase.

<Figure 3 here>

3.3.2. Parental attitudes and behaviours

Parental attitudes and behaviours towards food were measured on a Likert scale from 1-5, ranging from ”I do not agree at all” to ”I completely agree”. Four latent variables were fitted to the current study from a validated Norwegian questionnaire (Oellingrath, Hersleth, and Svendsen, 2013): Parental health attitude, Parental sugar attitude, Parental use of food rewards and Parental Taste Attitude. They are each measured by two indicators (Table 2). Some variables have been reversed. The questionnaire was used as it both included all relevant variables, and were made for the Norwegian marked.

3.3.3. Demographics

The questionnaire also included the measured variable older siblings, measured with the open question “Does your child have any siblings they live with?” which is coded into no older siblings (0), and older siblings (1). This study included two measured variables as control variables; gender and age. Gender consisted of male (0) and female (1) categories, whereas differences due to age is measured with comparing the preferences scores for Year 1 with the preference scores for Year 2 for each individual child, and comparing the model for Year 1 and Year 2.

3.4. Research model

The relations between sweet preferences and the influencing factors are investigated using path modelling employing the model in Figure 4. A path model describes the relation between not directly observational variables (latent variables/constructs) and observational variables (measured variables). In the graphical representation of the model (Figure 4) the latent variables are ovals, whereas the measured variables are squares. A path model consists of both a measurement model (outer model), which describes the relation between the indicators and the

latent variables, and a structural model (inner model), which describes the relationship between the latent variables and the measured variables. The indicators to each latent variable are described in Table 2.

According to the model in Figure 4, sweet preference is influenced by all other variables in the model, either directly or indirectly. Food exposure (Sweet food and snacks, Fruit, and Bitter snacks) is influenced by parental attitudes (Parental health attitude, Parental sugar attitude, Parental taste attitude, and older siblings). In path modelling, variables influenced by other variables are called endogenous, and have at least one in-arrow pointed towards them (here, Sweet Preference, and the three food exposure variables). The variables that influence other variables are referred to as exogenous variables and have only out-arrows. The exogenous variables are either measured variables (here, older siblings and the two sensitivity variables sweet and bitter), or latent variables (here, Parental health attitude, Parental sugar attitude, Parental taste attitude, and Parental use of food rewards) with indicators. In path modelling the latent variables can be reflective (i.e. the indicators are caused by the latent variable) or formative (indicators cause the latent variable), here the reflective mode is applied. In addition, gender is used as a control variable.

<Figure 4 here>

3.5. Statistical Analyses

3.5.1. Factor analysis

To decide on latent variables for the food exposure data, Confirmatory Factor Analysis was used. It was concluded that food exposure consists of three latent variables. Five components had eigenvalues exceeding 1, and the scree plot revealed a break after the third component. Seven, ten, and three indicators loaded substantially on each of three components, and these were

therefore kept as the indicators for these three variables. The additional ten food items were rejected, as they loaded either on more than one variable, or on the fourth, which was not conceptually sound as a variable.

3.5.2. PLS-SEM

The main analysis employed path modelling or structural equation modelling (SEM), in particular partial least-squares modelling (PLS-SEM). PLS-SEM is an iterative procedure for estimating the relationship between blocks of observed variables through a latent variable. PLS-SEM was used for several reasons, most importantly the wish to predict differences in sweet preferences, and to develop the theory further, both of which PLS-SEM is well fitted for (Hair, Hult, Ringle, and Sarstedt, 2016). Additionally, PLS-SEM was suitable to the small sample size in this study (Chin and Newsted, 1999).

In PLS-SEM, it is particularly important to validate the model. In the measurement model, several measures are applied to evaluate different aspects of reliability and validity for the reflective variables, in particular unidimensionality of the indicators (internal consistency reliability), how well indicators are described by their latent variables (convergent validity) and that the latent variables are different from each other (discriminant validity). Composite reliabilities and Cronbach's alpha are included to investigate the internal consistency reliability. They are both reported, as one is often overestimating internal consistency reliability, and the other too conservative, respectively (Hair et al., 2016). The measure used to investigate convergent validity is average variance extracted (AVE). To investigate the reliability of the measurement model, we present the standardised loadings (i.e. relation between) of each indicator on the respective latent variable. The discriminant validity is measured by considering the size of the cross-loadings, which is an indicator's outer loading on the associated latent

variable. Additionally, the heterotrait-monotrait ratio (HTMT) is included to investigate if the constructs in the model measure different concepts.

To assess the structural model, four measures are included. Firstly, to examine collinearity, VIF-values are included. The coefficient of determination (r^2) is examined to measure the model's predictive power. Finally, to investigate the hypotheses presented in this study, we applied one-tailed significance testing, as all the hypotheses have direction. To assess the associations between the variables, we use estimated path coefficients and the corresponding p-values. P-values and tests for path coefficients were obtained using bootstrapping (Hair et al., 2016).

3.5.3. Age effect

To control for the influence of age, the model was run twice, using the data from the Year 1, and Year 2. The relationships between the variables were examined, using the path coefficient estimates and the p-values. The associations were generally the same, but similar or stronger at the second year than at the first one. The results reported are therefore from the Year 2, which is the year the children turned five. To further investigate age-differences, two repeated measures ANOVAs were conducted, using sweet preference in drink or chocolate, respectively, as the dependent variable, comparing the scores of each child at Year 1 and Year 2.

All analyses were conducted using Smart-PLS 3.5 (Ringle, Wende, & Will, 2005), except for the repeated measures ANOVAs and the Confirmatory Factor Analysis, which were conducted using SPSS (version 23, 2015, IBM, Armonk; NY).

4. Results

4.1. Controlling for age

No main effect of age on preference was found in the repeated measures ANOVAs, neither for chocolate, ($F(1,97)=.001$, $p=.973$), nor for drinks ($F(1,97)=18.611$, $p=.068$). There was a small increase in preference for sweetness in drink, which can be seen in Figure 5, with an increase in preferring the sweetest drink rising from 48% to aged 59% between the years. As can be seen from Figure 5, the sweetest drink was the most preferred. For chocolate, there was only negligible differences were present, and there is no clear general favourite between the samples. The results presented from now on are only from Year 2.

<Figure 5 here>

4.2. Reliability and validity for the latent variables

The reliability and validity of the latent variables in the model presented in Figure 4, were investigated through the PLS-SEM. The model included seven latent variables, which are all reflective. The standardised loadings are presented in Table 2 together with the validation parameters, Cronbach's alpha, composite reliabilities, AVE, and HTMT-intervals. The standardized loadings were not all above the suggested threshold of .07, but the ones below were kept, as they were close, and contributed to the content validity of the model. As well contributing to the convergent validity, the average variance extracted (AVE) values were all above .50, indicating that the construct explained more than 50% of the variance in their indicators.

Regarding the internal consistency reliability, all variables had levels above .60 and below .95 using both Composite reliability and Cronbach's alpha. The HTMT values were all well below .85, the suggested threshold (Henseler, Ringle, and Sarstedt, 2015), indicating that the constructs in the model measure different concepts. Additionally, all indicators had outer loadings higher

353 than the cross-loadings on the associated construct, ensuring discriminant validity. The bootstrap
354 confidence intervals did not include the value 1, indicating that the constructs are empirically
355 distinct (Hair et al., 2016).
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Table 2: The measurement model: Reliability and validity for the latent variables and indicators.

Latent variable Indicator	**Loadings**	**Cronbach's alpha**	**Composite reliability**	**AVE**	**HTMT-interval**
Parental health attitude		.721	.807	.676	.007-.769
"I give my child what he or she likes, and do not care how healthy the food is" (R)	.794				
"I care about the healthiness of the foods my child eats"	.612				
Parental sugar attitude		.707	.787	.550	.017-.769
"I avoid giving my child high-sugar food and snacks" (R)	.690				
"I don't think about the total level of sugar my child consumes on a daily basis"	.763				
Parental taste attitude		.682	.823	.748	.017-.208
"I always choose food for my child that tastes good"	.702				
"I think healthy foods taste good"	.845				
Parental use of food rewards		.776	.842	.541	.019-.073
"I reward my child with food"	.907				
"I believe it is wrong to spoil children with candy" (R)	.642				
Sweet foods and snacks		.718	.793	.662	.196-.603
Candy	.572				
Brown cheese	.554				
Baked goods	.761				
Ice cream	.706				
Cakes	.793				
Chocolate milk	.466				

Chocolate spread	.577				
Fruit		.857	.880	.505	.172-.269
Oranges	.673				
Boysenberry	.637				
Blueberry	.655				
Apple	.630				
Strawberry	.719				
Kiwi	.788				
Clementine	.652				
Mango	.539				
Passion fruit	.712				
Pear	.565				
Bitter snacks		.715	.727	.595	.064-.517
Walnuts	.688				
Dark chocolate	.895				
Olives	.659				

Indicators marked (R) are reversed.

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359 *4.3. Hypothesis testing*

360 The predictive model for sweet preference is summarised in Table 3. This model has a predictive
361 power of r^2=.36 for Sweet preference in drink, and an r^2 of=.28 for Sweet preference in chocolate,
362 which is respectively moderate and weak (Hair et al., 2016). The predictive model relating food
363 exposure to sensitivity and parental behaviour is summarised in Table 4. The predictive power of
364 this model is moderate for Sweet foods and snacks (r^2=.38), but quite weak for Fruit as well as
365 Bitter snacks, with levels of .21 and .25, respectively.
366 To investigate collinearity, VIF-values are reported in Table 3 for preferences, and Table 4, for
367 food exposure. All variables have a VIF-value below five, and thus there is not a critically high
368 collinearity between the variables.

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Table 3:
Collinearity and estimated total effects between predictor variables and preference in sweet drink and chocolate.

	Preference in sweet drink			Preference in chocolate	

Endogenous variable	VIF	Path coef. estimates	p-values	VIF	Path coef. estimates	p-values
Sweet sensitivity	1.10	.072	.05	1.60	.021	ns
Bitter sensitivity	1.34	.004	Ns	1.52	.107	.045
Sweet foods and snacks	1.59	.023	.02	1.36	.189	.003
Fruit	1.34	.220	.007	1.32	.163	ns
Bitter snacks	1.52	.056	Ns	1.35	.082	.04
Gender	1.17	.154	.008	1.16	.025	.006
Use of food rewards	1.20	.090	.02	1.08	.041	.03
r^2	.36			.28		

Ns = not significant at .05 level.

4.3.1. Controlling for gender differences

As can be seen from the path coefficient estimate in Table 4, girls preferred both sweeter drinks and chocolate more than boys did, with the association stronger in drinks.

4.3.2. H1: Associations between diet and sweet preferences

More frequent exposure to sweet foods and snacks was associated with a higher sweet preference in both drinks and chocolate. Children more often exposed to fruit preferred lower sweetness in drink, but there was no association with chocolate. Higher exposure to bitter snacks was associated with a higher preference for the more bitter chocolate, and thus less sweet. These associations are all in line with the proposed relationships in H1. All significant relationships are shown with the Path Coefficient estimate as well as the p-values in Table 3.

Table 4:
Collinearity, and estimated total effects, between predictor variables and Sweet foods and snacks, Fruit, and Bitter snacks, respectively.

	Sweet foods and snacks	Fruit	Bitter snacks

Variable	VIF	Path coef. estimate	p-value	VIF	Path coef. estimate	p-value	VIF	Path coef. estimate	p-value
Sweet sens.	1.10	.363	.002	1.10	.012	ns	1.07	.096	ns
Bitter sens.	1.05	.127	ns	1.07	.010	ns	1.07	.374	.009
Health attitude	1.28	.471	.006	1.02	.357	.007	1.23	.086	ns
Sugar attitude	1.11	.114	.045	1.03	.008	ns	1.60	.076	ns
Taste attitude	1.12	.207	.006	1.01	.046	ns	1.04	.055	ns
Older siblings	1.14	.119	.048	1.16	.038	ns	1.23	.036	ns
r^2	.38			.21			.25		

Ns = not significant at .05 level.

4.3.3. H2: Direct and indirect associations between sweet preferences and parental attitudes and behaviours

Higher parental use of food rewards was related to a preference for both the higher sweet chocolate and drink.

Parents that scored higher on health attitude, sugar attitude, and/or taste attitude, exposed their children to less sweet foods and snacks. Additionally, a high parental score on health attitude was associated with higher fruit exposure for their children. Children with older siblings were more exposed to sweet food and snacks. All significant associations are in line with the proposed relationships in H2. All relationships are shown with the Path Coefficient estimate as well as the p-values in Table 4.

4.3.4. H3: Direct and indirect associations between sweet preference and sensitivity.

Children more sensitive to sweetness significantly preferred the less sweet drinks, but the association was small. More bitter sensitive children preferred lower sweet and more bitter

chocolate. Sensitivity also had an indirect association with preferences: Children more sensitive to sweetness were less frequently exposed to sweets. These associations are in line with H3. Additionally, there is an interesting association between sensitivity to bitterness and exposure to bitter snacks, with children more sensitive to bitter taste actually being more frequently exposed to bitter snacks than the other children are. All relationships are shown with the Path Coefficient estimate as well as the p-values in Table 4.

5. Discussion

This study expands upon previous findings regarding sweet preferences in pre-schoolers, and highlights that preferences can be influenced by individual and family factors, both directly and indirectly. Better knowledge in this area is relevant for health authorities, the food industry, parents and researchers.

As there is no longitudinal comparable studies to our knowledge, it is particularly interesting that we did not find an age-effect, which has previously been found in cross-sectional studies (Cooke and Wardle, 2005; Lanfer et al., 2013). However, as the children only aged twelve months between data collections, the lack of significant difference is not surprising. The same factors were associated with sweet preference at both years of data collection, which is also expected, as the factors investigated should be quite stable, in particular parental attitudes and behaviours. The associations were stronger at age five, when the child's environment and food habits may have had a longer time to influence preferences. This points towards that an age effect could emerge with a longer study.

The girls had a significantly higher sweet preference than boys did for both chocolates and drinks, which was not found in the most directly comparable study in terms of protocol and age (Liem, and de Graff, 2004). As there was no other gender differences in neither food exposure,

sensitivity, nor parental attitudes and behaviours (data not shown), and the association was consistent for both drinks and chocolates, this might mirror an actual higher sweet preference among girls than among boys. As there seems to be an increase in sweet preference within the childhood years, the gender difference might be due to the girls being more mature than the boys, indicating that the boys will catch up eventually.

The importance of parents in shaping their children's sweet preferences is evident, as parental attitudes were associated with the children's exposure to foods, which again was associated with their preference for sweetness. However, the associations were mostly weak or moderate. This could be explained by the fact that the children have not been exposed to foods for many years yet – 4.5 years at most. However, Nicklaus and colleagues (2004) found that the preschool years are of particular importance to shape food preferences. Therefore, our results indicate that although there is a significant association between food exposure and taste preferences, it is not very large, and other factors are also important in shaping taste preferences.

The associations between parental health attitude and fruit and sweet food exposure, respectively, are in line with previous studies where mothers' higher health knowledge and actions were associated with higher consumption of fruit in their children (Gibson, Wardle, and Watts, 1998), and lower serving of sugared foods (Schneider et al., 2013). It is also in line with The Norwegian Directorate of Health (Helsedirektoratet, 2015), which recommends eating at least two fruits every day, and limiting consumption of high-energy candy and snacks. Even though this information is easily available for all in Norway, parents with a high health-conscious attitude put higher importance on the healthiness of the foods they expose their children to, and would therefore better follow these recommendations.

448 We found an association between parental sugar attitude and sweet foods and snacks, but not fruit
449 or bitter snacks. We expected that parents with a more restrictive sweetness attitude would not
450 only serve less sweet foods and snacks, but would substitute sweet foods with something else, but
451 this could be wrong, or the parents could substitute with food items not included in this study.
452 Parental taste attitude also had a significant association only with exposure to sweet foods and
453 snacks. This was unexpected, as in particular the item "I think healthy foods taste good" was
454 theorized to have a relationship with fruit, as fruit is recommend as being healthy
455 (Helsedirektoratet, 2015), and parents who serve more fruit would be expected to believe to a
456 higher degree that fruit tastes good (Skinner et al., 2002). This points towards the children's
457 exposure to fruit being more based on parental health attitude than if the parents believe the taste
458 of fruit is good or not. Supporting this, a study using a larger version of the same questionnaire as
459 we did, found a stronger relationship between parental health attitude and an actual healthier diet,
460 than of parental taste attitude and healthy diet (Oellingrath, Hersleth, and Svendsen, 2013). The
461 study did however include older children (age 12-13) than the present one, and a larger item
462 battery for the questionnaire, indicating that more research on association between parental taste
463 attitude and children's exposure to different foods would be interesting.
464 As expected, parental use of food rewards had a significant effect on both drink and chocolate,
465 supporting previous findings where giving something sweet as a reward increases sweet
466 preference (Birch and Fisher, 1998; Newman and Taylor, 1992). However, the association could
467 also be explained by children with a high sweet preference been given more sweet rewards, since
468 the reward would influence them more than their peers.
469 In addition to attitudes, the foods parents expose their children to are guided by practical factors
470 such as family size, shown by the heightened exposure to sweet foods and snacks for children
471 with older siblings. Interestingly, the lack of association between fruit and having older siblings

indicate that perhaps the presence of older siblings increases exposure to unhealthy foods more than exposure to healthy ones.

More sweet sensitive children were less exposed to sweet foods and snacks than the other children. For the sensitive children, sweet food would have a higher sweet intensity of taste, which could be the reason why they are exposed to fewer sweets – the taste is too strong for them. Another possible explanation might be that the parents of the most sweetness sensitive children are also more sensitive, and therefore provide fewer sweets, as the taste would be too intense for them as well.

The lack of associations between bitter sensitivity and sweet drink neither supports our hypothesis or previous studies (Duffy, Peterson, Dinehart & Bartoshuk, 2003; Hayes & Duffy, 2008) finding that a higher bitter sensitivity would lead to a lower preference for sweetness. However, the association was present for chocolate: More bitter-sensitive children preferred more bitterness in chocolate, and thus to a lesser degree sweetness. This points towards the difference in preference not being due to sweetness, but rather to differences in preference for bitterness. As the more bitter sensitive children in this study are more frequently exposed to bitter snacks, these children could have a higher bitter preference due to it being more familiar. Hypothesis H3 is therefore only partly supported. However, bitterness is a complex taste, and the results could have been different if other bitter taste agents had been used, both in the chocolate (cocoa) and for the sensitivity test (quinine). This highlights the need for more research, with additional food products.

Previous studies have indicated that the exact preferred level of sweetness in a product is food-specific (Holt, Cobiac, Beaumont-Smith, Easton, and Best, 2000). However, people tend to have

low, medium, or high sweet preference across products (Holt et al., 2000). We therefore investigated if the same factors would be associated with sweet preference in two different, but child-friendly taste carriers. Generally, the tendency is that the same associations are found between the variables and the sweet preferences in both taste carriers, at least where it would be expected. We argue that finding similar associations in two quite different taste carriers (one solid and one liquid) heightens the generalizability of the study.

Limitations

It is important to keep in mind that the results from this study are not necessarily applicable to other sweet stimuli than the beverages and dark chocolates that were selected. Different food samples and sweetness intensities might have given quite different results. This study can therefore only be compared with other studies with great caution (Mojet, Christ-Hazelhof, and Heidema, 2005) – for example, the high sweet concentration in this study could be more similar to a medium sweet concentration in another study.

The food indicators in this study are chosen because they both a) are high on either sweetness or bitterness, and b) fitted in the factor analysis, excluding several interesting foods, such as sodas. Different food indicators could lead to different results. Additionally, although the sweet food items are all sweet per se, several of the food items, such as cake and baked goods, are often made at home, and could therefore easily differ in sugar content between the families in this study. Highlighting this limitation, a similar study with the same age group found a positive association between sweet preference and added sugar level in the child's favourite cereal (Liem and Mennella, 2002). Investigating the association between total sugar consumption and taste preferences would be very interesting, but we chose to focus on foods hgh on particular taste intensities instead.

6. Conclusion

This study aimed at understanding how parental attitudes and behaviours as well as taste sensitivity can influence sweet preferences in pre-schoolers. A protocol using ranking by elimination with two different types of taste carriers (chocolates and drinks with three levels of sweetness) were used with 138 children aged five (mean age 57.5 months, SD 3.3). Our research expands on the existing literature regarding sweet preferences, and underlines the importance of parental impact on sweet preferences. Additionally, we elaborate on the link between preferences and taste sensitivity, and suggest the need for more research on the impact of bitter sensitivity for both bitter and sweet preferences. Even though the majority of trends in this study were found in two different taste carriers, further research may investigate different taste carriers, to understand if there is a general impact of parental behaviours and taste sensitivity on sweet preference, or only in particular products.

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Figure 1: Spider plot of the three sweet drinks, with attributes evaluated by a professional sensory panel. The blue line represents the drink with the highest amount of sugar (18%), the green line the drink with medium amount (12%), and the red line the low level of sugar (4%). There was a significant difference for sweetness, and taste intensity, acidity, richness, astringency, and cloying taste.

Figure 2: Spider plot of the three sweet chocolates, with attributes generated by a professional panel. The blue line represents the chocolate sample with the highest amount of cocoa (65% cocoa) and thus the least sweet chocolate, the green line the medium bitter (55% cocoa) and sweet sample, and the red line the least bitter (45% cocoa) and thus highest sweet taste There were three significantly distinct levels of sweetness and bitterness, as well as all other attributes represented in the plot, except sour taste and sour odour.

Figure 3: Exposure to at least one of the indicators in the variables Fruit, Bitter snacks, and Sweet foods and snacks, respectively, either daily, weekly, monthly, at least once, or never. Given in percentages.

Figure 4: Research model. Sweet preference (in either drink or chocolate) and the three Food Exposure variables are used as the endogenous variables in the PLS-SEM model. The exogenous variables are the two taste sensitivity variables, and the variables regarding Parental attitudes and behaviours. Gender is included as a control variable. The latent variables are represented with ovals, and the measured variables with boxes. Solid lines represents association with food exposure (H1), striped lines the parental influence (H2), and dotted lines the association with sensitivity.

Figure 5: Children's preference scores for each sample in drink (to the left) and chocolate (to the right). The figure compares the children at age 4 and at age 5, with striped beams for age 5.